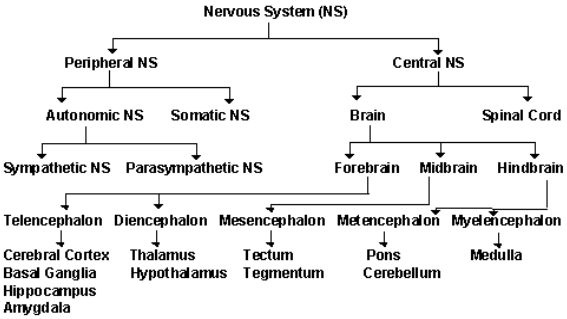
The Nervous System



· Explain the basic structure and function of the central nervous system. (116-7, 317-1)
· Describe the basic functions of a peripheral nervous system. (116-7, 317-1)
· Investigate the physiology of reflex arcs. 212-6, 213-4, 213-5, 214-10, 215-2)
· Describe how the nervous system helps maintain homeostasis. (317-1)

3

The Nervous System

- Has two parts:

1) **Central Nervous System** - brain and spinal cord

2) **Peripheral Nervous System** - the nerves leading into and out of the central nervous system

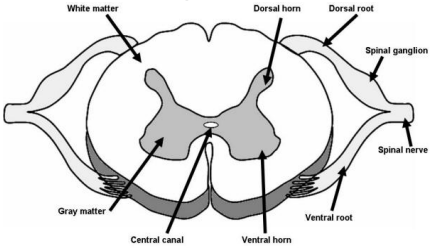
The Central Nervous System (CNS)

- receives sensory information and initiates motor control

- protected by:
  - the skull
  - vertebrae enclosing the spinal cord
  - meninges - protective membranes that surround the brain and spinal cord that is filled with cerebrospinal fluid

- the spinal cord is the vehicle of communication between the brain and the peripheral nervous system (PNS)

- the spinal cord is composed of
  1) a central canal - filled with cerebrospinal fluid
  2) grey matter
  3) white matter



Grey Matter
- neural tissue that contains sensory neurons, motor neurons, and interneurons

White Matter
- surrounds the grey matter
- contains myelinated axons of interneurons that carry information to the brain and body

The Peripheral Nervous System (PNS)

- consists of the somatic and autonomic nervous system

Somatic Nervous System
- under conscious control to some degree
- consists of sensor nerves and motor nerves
- deals primarily with the external world
- responsible for **reflex** reactions - eye blink when something goes near your eye

Autonomic Nervous System
- not consciously controlled
- made up of sympathetic and parasympathetic nervous system

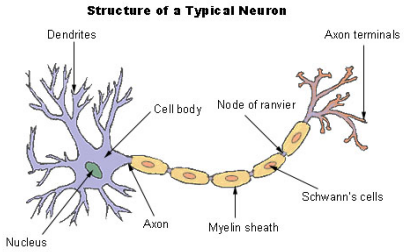
Sympathetic Nervous System (SNS)
- controls the fight or flight response
- when stimulated heart and respiration rate increases

Parasympathetic Nervous System
- responsible for slowing down heart and respiration rates (reverse the effects of the SNS)

Neurons and the Reflex Response

- a reflex arc is the pathway that leads from stimulus to reflex action

Neurons
- functional unit of the nervous system is the neuron
- nerves are simply numerous neurons held together with connective tissue
- consists of three parts
  - cell body
  - dendrites
  - axon



Neurons

The messages carried by the nervous system are electrical signals called impulses.

The cells that transmit these impulses are called **neurons**.

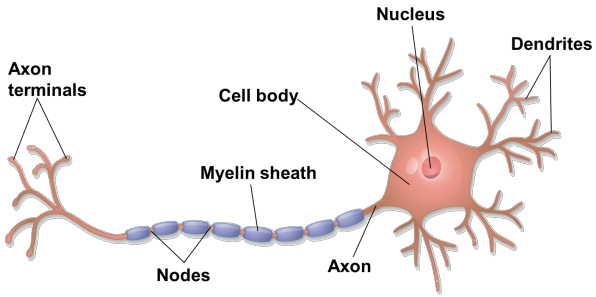
Neurons are classified according to the direction in which an impulse travels.

- Sensory neurons carry impulses from the sense organs to the spinal cord and brain.

- Motor neurons carry impulses from the brain and spinal cord to muscles and glands.

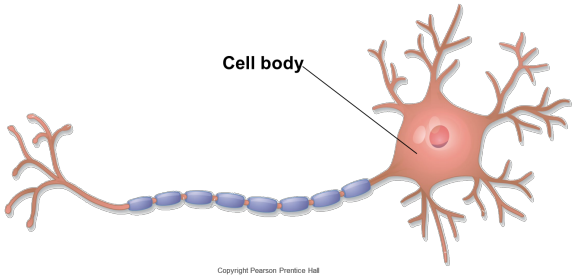
- Interneurons connect sensory and motor neurons and carry impulses between them.

Structures of a Neuron

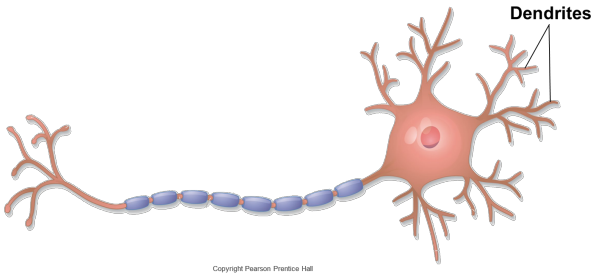


The largest part of a typical neuron is the **cell body**.

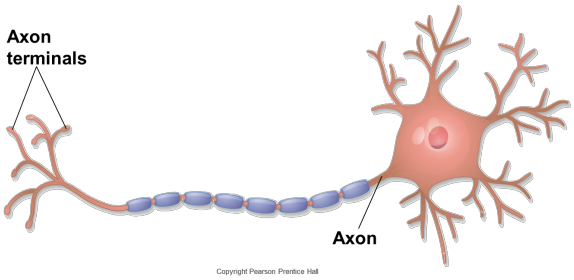
It contains the nucleus and much of the cytoplasm.



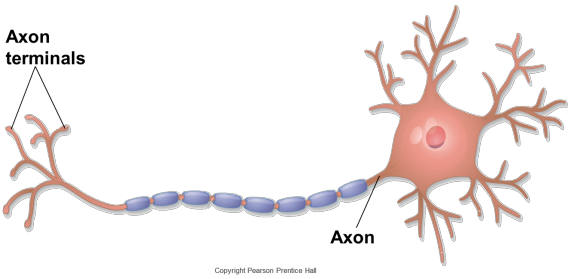
Dendrites extend from the cell body and carry impulses from the environment toward the cell body.

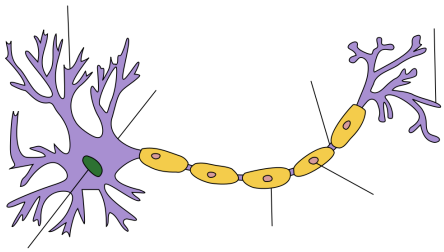


The **axon** is the long fiber that carries impulses away from the cell body.



The axon ends in axon terminals.

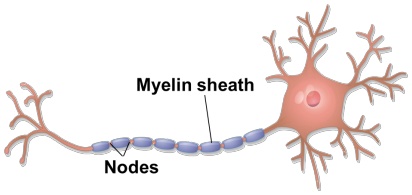




The axon is sometimes surrounded by an insulating membrane called the **myelin sheath**.

There are gaps in the myelin sheath, called nodes, where the membrane is exposed.

Impulses jump from one node to the next.



The Nerve Impulse

The Resting Neuron

When resting, the outside of the neuron has a net positive charge.

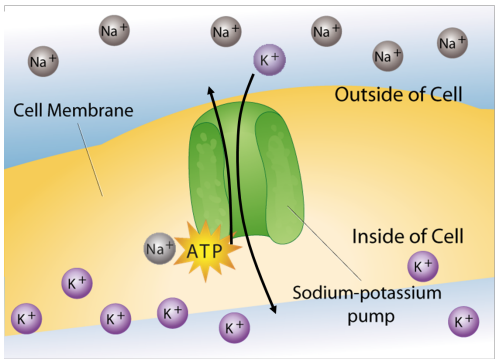
The inside of the neuron has a net negative charge.

The cell membrane is electrically charged because there is a difference in electrical charge between its outer and inner surfaces.

The sodium-potassium pump in the nerve cell membrane pumps sodium (Na^+) ions out of the cell and potassium (K^+) ions into the cell by means of active transport.

As a result, the inside of the cell contains more K^+ ions and fewer Na^+ ions than the outside.

Sodium-Potassium Pump



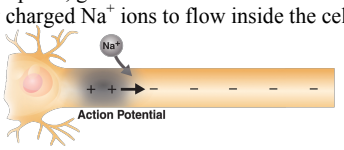
More K^+ ions leak across the membrane than Na^+ ions. This produces a negative charge on the inside and a positive charge on the outside.

The electrical charge across the cell membrane of a neuron at rest is known as the **resting potential.**

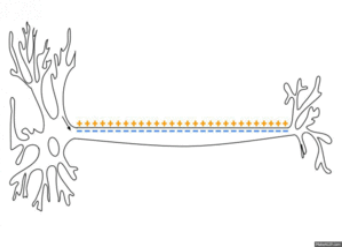
The Moving Impulse

- an impulse begins when a neuron is stimulated by the environment or another neuron

- At the start of the impulse, gates in the sodium channels open allowing positively charged Na^+ ions to flow inside the cell membrane.

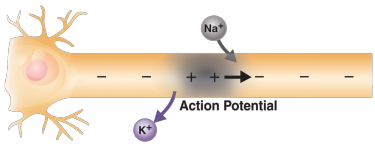


- The inside of the membrane becomes temporarily more positive than the outside (reverse of the resting potential) to create what is known as the action potential



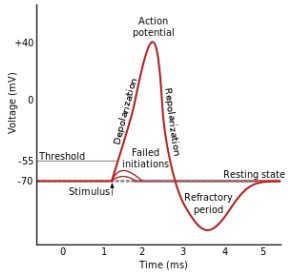
When the sodium channels close the process of actively transporting the Na^+ ions back out begins.

As the action potential moves gates in the potassium channels open allowing K^+ ions to flow out - restoring the axon to resting potential.



Threshold

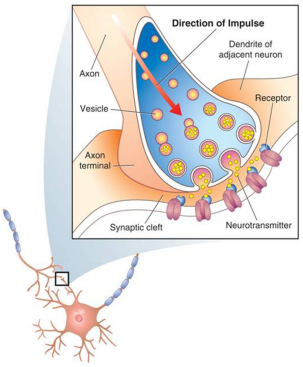
- stimulus must be of a specific strength to cause a neuron to transmit an impulse. This minimum level of strength is called the threshold.
  - stronger than threshold = impulse
  - weaker than threshold = no response



The Synapse

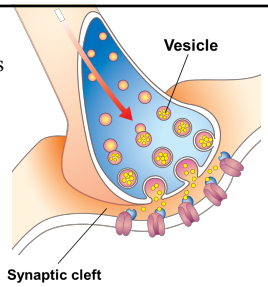
- at the end of the neuron the impulse reaches an axon terminal. This is the point where the impulse needs to be transferred to another cell.

- location of the point of transfer is called a synapse



- the **synaptic cleft** separates the axon terminal from the dendrites of the adjacent cell

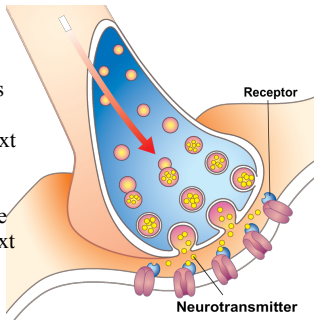
- terminals contain vesicles filled with **neurotransmitters**
  - chemicals used by the neuron to transmit an impulse across a synapse to another cell



- As an impulses reaches the terminal, vesicles release neurotransmitters into the synaptic cleft to diffuse across the cleft and attach to membrane receptors of the next cell

- Na^+ ions then travel across the membrane to stimulate the next cell

- if stimulation exceeds the threshold of the new cell an impulse begins.



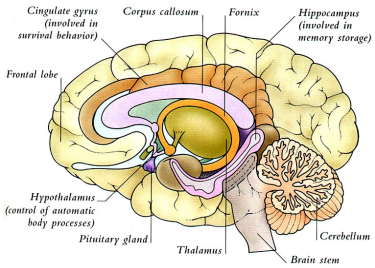
THE BRAIN

Medulla Oblongata
- is located at the base of the brain and attaches to the spinal cord.
- has three functions:
  - cardiac center - controls heart rate
  - vasomotor center - controls blood pressure
  - respiratory center - controls the rate and depth of breathing

Cerebellum
- controls muscle co-ordination
- must physical skills we learn are eventually taken over by the cerebellum

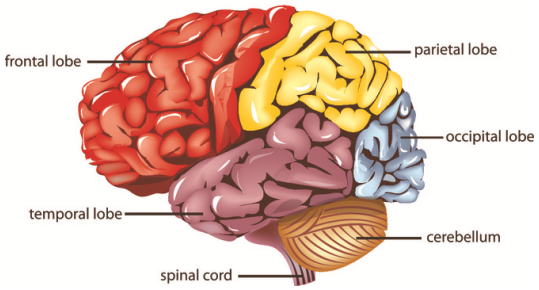
Thalamus - sensory (touch, pain, temperature, ...) relay center
- mild sensations are sent to the cerebrum while strong sensations are sent to the hypothalamus

Hypothalamus - main control center of the autonomic nervous system



Cerebrum - sorts and interprets information from our senses
- control center for voluntary movement and speech
- responsible for storing memories and making decisions
- divided into the left and right hemisphere
- also divided into four lobes:
  - frontal lobe - motor and info integration area
  - parietal lobe - receives sense info and associated with taste
  - occipital lobe - receives info from our eyes
  - temporal lobe - receives info from our ears

Parts of the Human Brain



Cerebral Cortex - thin layer of cells that cover the left and right hemisphere and is composed of grey matter

Corpus Callosum - thin layer of white matter that joins the left and right hemisphere

How do the following disorders effect the nervous system:

1) Multiple sclerosis (MS)
2) Alzheimer's disease
3) Parkinson's disease
4) Meningitis
5) Huntington's disease

Drugs and the Nervous System

- Drugs can be categorized as nervous system depressants or stimulants
  - depressants - cause a person to relax and feel less pain.
    - can also cause a loss of coordination and judgment
    - ex. alcohol, heroin, valium
  - stimulants - speed up the CNS
    - includes caffeine, cocaine, nicotine
- Anaesthetic drugs - work by disrupting the sodium channels of the neurons

- Describe disorders linked to the nervous system and their effect on the homeostasis of the system and the organism as a whole. (317-1, 317-4)
  - Describe how the use of drugs can have a role in disrupting homeostasis. (317-7)

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  - Describe how the use of prescription and non-prescription drugs can have a role in maintaining or disrupting homeostasis. (317-7)

The Endocrine System

- comprises the hormone-producing glands and tissues of the body.

- works in conjunction with the nervous system to maintain homeostasis in the body

- hormone - chemical substances that circulate through the blood and exert some measure of control over virtually every organ and tissue in the body
  - levels are regulated by changing metabolic needs

- target organs - an organ that contains receptors for a particular hormone

Endocrine Glands - ductless glands that secrete hormones into blood stream

Exocrine Glands - release their secretions through ducts or tubes ex. sweat glands

Types of Hormones

1. Steroid Hormones - made from cholesterol in the smooth ER
- when secreted in the blood they must bond with a protein carrier molecule due to the fact that they are hydrophobic
- generally enter cells to have an effect
ex. cortisol

2. Non-steroid Hormones - composed of proteins, peptides or amino acids
- bond to receptors to have an effect
ex. adrenaline

Antagonistic Hormone - hormones that have opposing physiological properties, but that work together

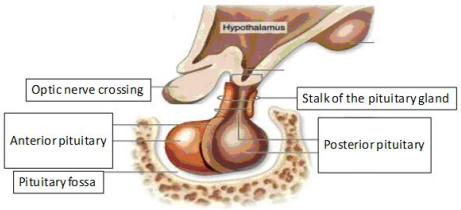
An Overview of the Major Endocrine Glands

1) The Pituitary Gland
- the master gland
- connected to the hypothalamus by a network of blood vessels (allows for the nervous system to have some control over the gland and other glands)
- produces hormones that regulate hormone production in other glands - releases hormones to stimulate other glands
- composed of two glands (anterior and posterior pituitary)

Anterior Pituitary
- produces a) Human Growth Hormone
- insufficient levels = pituitary dwarfism
- excess levels = gigantism
b) Prolactin - stimulates the development of mammary gland tissue and milk production

Posterior Pituitary
- produces: 1) Anti-diuretic hormone (ADH) - release triggered by sodium levels in the blood and blood pressure
2) Oxytocin - triggers contractions during childbirth and the release of milk from the breasts

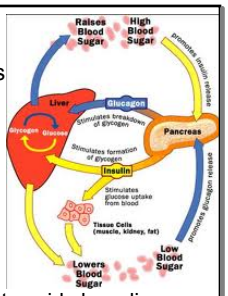
Anatomy of Pituitary



2) Thyroid and Parathyroid
- located above the trachea
- embedded in the thyroid are 4 small parathyroid glands
- primarily responsible for producing thyroxin
  - made using iodine from our blood stream
  - increases metabolic rate and oxygen consumption
- also produces calcitonin - regulates calcium levels in the blood

Task: Create a working definition for each of the following disorders:
1) Grave's disease
2) Hypothyroidism
3) Goiter

3) Pancreas (both endocrine and exocrine)
- exocrine - secretes digestive enzymes
- endocrine - produces glucagon and insulin in the islets of Langerhans



Glucagon and Insulin
- regulate body's metabolism of sugar and carbohydrates
- Insulin - increases the intake of glucose, amino acids, and fatty acids by adipose tissue and causes the conversion of glucose to glycogen in the liver
- cause the uptake of glucose into cells

What is the difference between Type I and Type II Diabetes

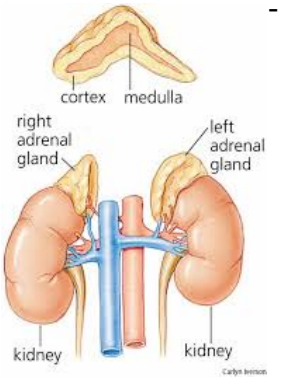
4. Pineal Gland
- pine cone shaped structure located in the brain
- produces melatonin - responsible for the feeling of sleepiness

5. Thymus Gland
- located between the lobes of the lungs
- produces thymosin - stimulates the production and maturation of lymphocytes and T cells
- usually disappears after adolescents (lymphocytes and T cells are then produced by the spleen

6. Adrenal Glands
- body has two (1 on top of each kidney)
- has two layers (outer cortex and inner medulla) each making different hormones
- the two layers don't interact but are controlled by the hypothalamus

Adrenal Cortex
- produces cortisol, aldosterone, androgens, progesterone, and estrogen
  - cortisol - stimulates carbohydrate synthesis and works as an anti-inflammatory
  - aldosterone - regulates salt and waste balance
  - androgen - sex hormone that promotes muscle and skeletal development
  - estrogen - levels are insignificant until after menopause
  - progesterone - regulates the lining of the endrometrium (inner lining of the uterus)

Adrenal Medulla
- composed of neurons from the sympathetic nervous system
- secretes adrenaline (epinephrine) and noradrenaline (norepinephrine)
  - act to increase heart rate and blood pressure, and cause vasodilation of vessels of the heart and respiratory system



The Eye

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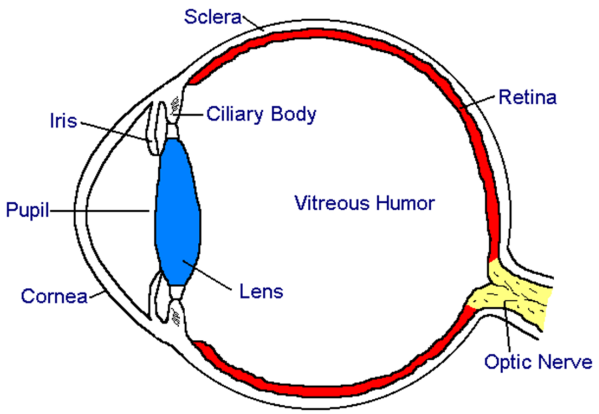
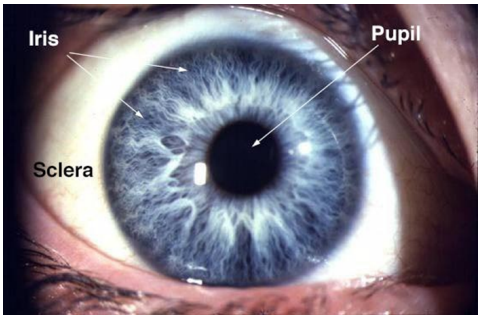


Structure and Function

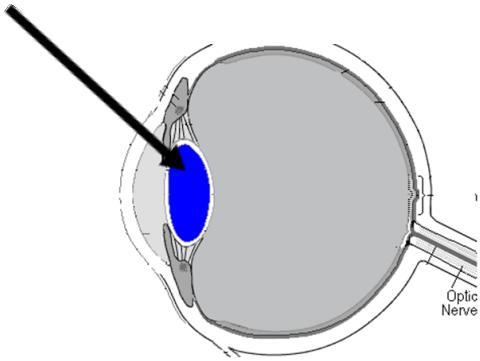
Iris
- colored part of the eye
- controls light entering

Pupil
- black hole in the iris
- where light enters

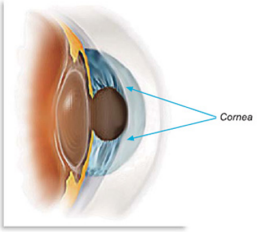


Sclera
- whites of the eye
- provides attachement for muscles

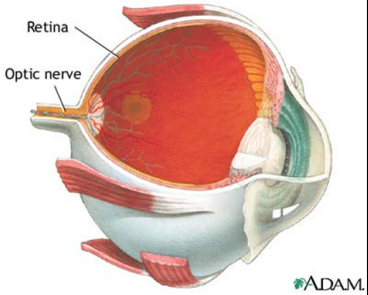
Lens
- allows us to see objects near and far



Cornea
- transparent bulge over pupil
- focuses light onto retina

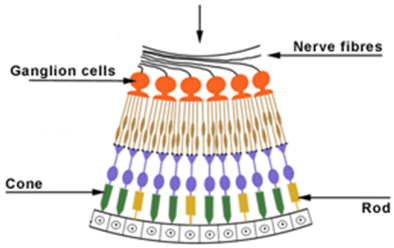


Retina
- contains light receptive cells (rods and cones)
- converts light to electrical signals

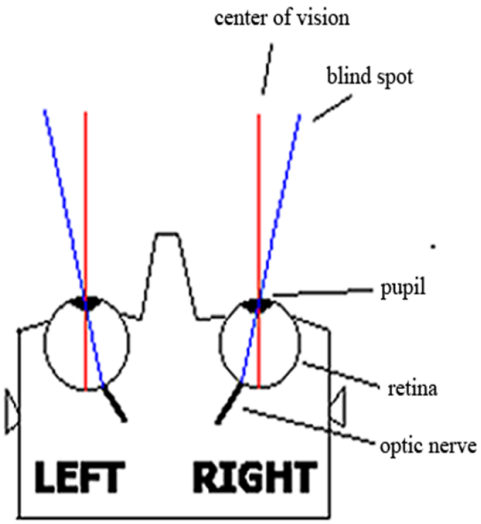


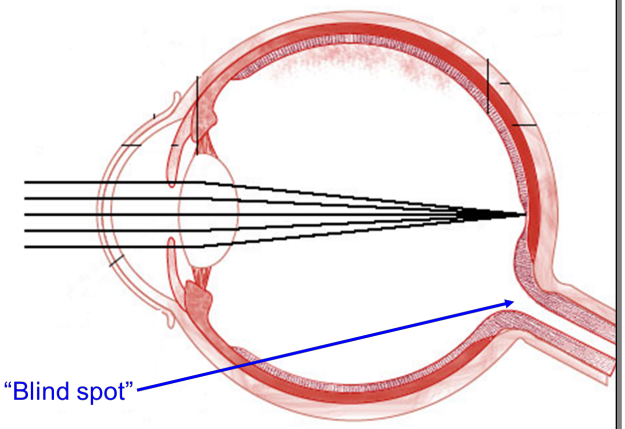
Rods
- 120 million cells
- detect brightness (black and white)
- for night vision

Cones
- 6 million cells
- detect color (RGB)
- designed to detect movement and patterns



Blind Spot
- on retina where optic nerve leads back into the brain
- no rod or cone cells
- other eye compensates for this area



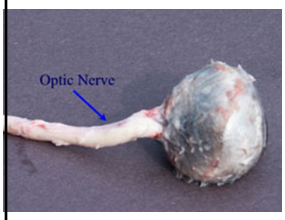


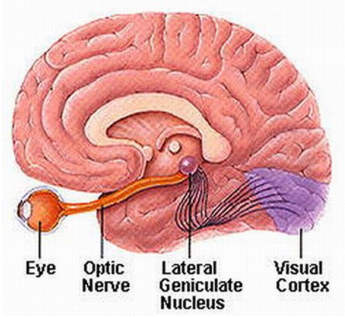
Blind Spot Test

Close left eye and approach screen while staring at the letters ... watch the dot!

a b c d e f g h
i j k l m n o p
q r s t u v w x

Optic Nerve
- transmits electrical impulses from retina to the brain
- creates blind spot
- brain takes inverted image and flips it so we can see





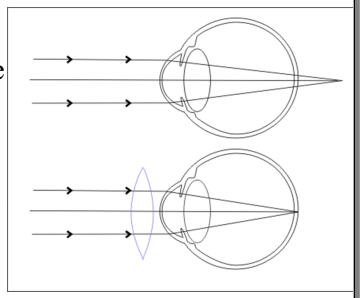
Far - Sighted (Hyperopia)

- problem seeing close objects

- distance between the lens and retina is too small

- light focused behind the retina

- corrected with a converging lens



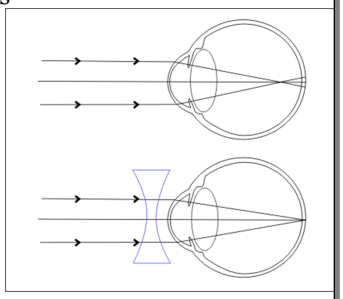
Near - sightedness (Myopia)

- problem seeing objects far away

- distance between lens and retina too large

- light focused in front of retina

- corrected with diverging lenses



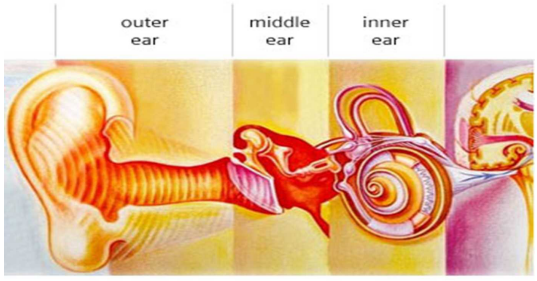
Tests for degree of peripheral vision.

Performed with visor-type device at your forehead.

1. Sit at the table and place the visor to your forehead.
2. Flap the focus marker down in the front.
3. Bring the handles together and hold on to them with both hands.
4. Rest your elbows on the table.
5. Have your partner choose a letter card at random. Do not tell the testing subject what it is.
6. Have your partner start with the clear swinging arm all the way back at 125° on the right side.
7. Focus both eyes on the tip of the focus marker.
8. Your partner slowly moves the letter card towards the front of the visor.
9. Keep your eyes focused on the tip of the focus marker.
10. Tell your partner as soon as you see the card in your peripheral vision.
11. Your partner writes down the number where you first saw the card. This marks the edge of your field of vision.
12. Your partner keeps moving the letter card forward (towards the middle).
13. Tell your partner when you can read what the first letter on the card is.
14. Your partner writes down the number where you were first able to read the letter. This marks the edge of your reading field of vision.
15. Repeat the procedure for the left side.

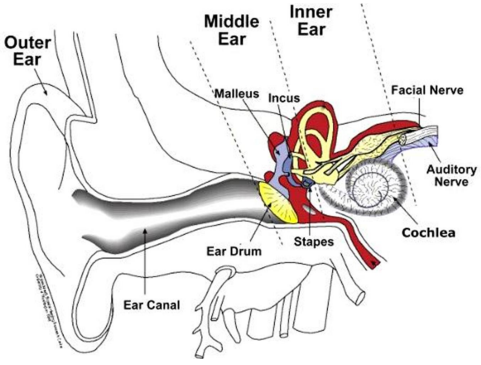
The Human Ear

Is divided into three sections.



The Outer Ear

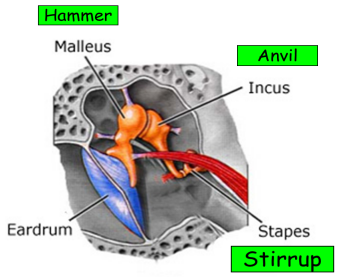
Acts like a satellite dish - the pinna (curved outside formation) collects sound waves and funnels them down the ear cannel to the eardrum



The Middle Ear

- transfers the energy from sound waves by vibrating three bones (Hammer, Anvil and Stirru

- they are the smallest bones o the body (size of an orange seed)



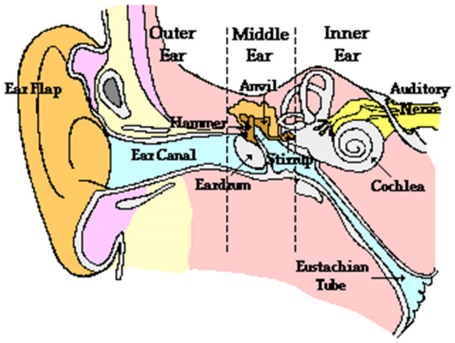
- When the sound waves reach the middle ear, they cause the eardrum to vibrate.

- This vibration then causes the three bones to vibrate.

- These vibrations are transformed into longitudinal / pressure waves in the middle ear.

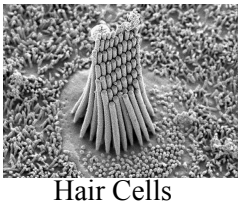
The Inner Ear

Two main parts
- cochlea
- auditory nerve



Cochlea
- coiled like a snail shell
- contains roughly 300 000 hair cells
  - these cells bend due to vibrations caused by sound waves
- filled with fluid to allow for sound passage

Auditory Nerve
- stimulated by the vibrations of the hair cells
- transmits the signal to the brain


Hair Cells

A sound is not actually heard until the brain receives and processes these signals

Put the following steps in order:

- The stirrup moves back and forth, creating pressure waves in the cochlea.
- The bones of the middle ear (hammer, anvil, & stirrup) vibrate.
- Hair cells send an electrical impulse through the auditory nerve.
- The outer part of the ear (the pinna) "catches" the sound waves.
- Sound waves vibrate the eardrum
- The brain receives an electrical impulse and interprets it as sound.
- Tiny hair cells in the cochlea move as the waves pass.
- The sound waves travel into the ear canal.

It is expected that students will:

- Diagram and explain the structure of a neuron. (317-1)
- Describe the basic structure and function of sensory neurons, motor neurons and interneuron"s, using the concept of the reflex arc. (317-1)
- Describe the transmission of an impulse. (317-1)
- Identify the role of certain compounds to neuron function: oxygen, glucose, ATP, sodium ions.(314-2)
- Explain, in general terms, the ion distribution on the membrane of a neuron and the influence of myelin. (317-1)

Biology 121

- Demonstrate an understanding of natural and artificial transmitters and inhibitors of the nervous system. (314-2, 317-1)

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It is expected that students will:

- Identify the location and function of principal endocrine glands in humans, and identify hormones, their source gland, and their general effect on humans. (116-7, 317-1, 317-2)
- Describe how the endocrine system helps maintain homeostasis. (317-1)
- Describe an example of neural and endocrine control systems acting together in animals. (116-7, 317-1, 317-2)
- Understand the general concept of a hormone and target cell or organ. (317-1)
- Explain how protein and steroid hormones cause changes in target cells. (314-3, 317-1)

Biology 121

- Design an experiment to investigate and collect data on selected aspects of the endocrine system and identify specific variables involved. (212-6, 213-4,

3

· Analyze homeostatic phenomena to identify the feedback mechanisms involved in the endocrine system. (317-2)
· Investigate the role played by Frederick Banting and Charles Best in the discovery of insulin. (117-11)
· Demonstrate an understanding of the relationship between human health and feedback loops (e.g. diabetes) (317-1, 317-4)
· Describe disorders linked to the secretions of the endocrine system and their effect on the homeostasis of the system and the organism as a whole. (317-1, 317-4)

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It is expected that students will:

· Describe the structure and function of the brain: meninges, cerebrospinal fluid, cerebrum, cerebellum, brain stem, thalamus, hypothalamus (317-1)

· Describe the general structure and function of the eye: lens, iris, cornea, retina, vitreous fluid, choroid, fovea, rods, cones, blind spot.
(116-7, 317-1)

· Describe the general structure and function of the ear: tympanic membrane, ossicles (hammer, anvil, stirrup), eustachian tube, semicircular canals, cochlea
(116-7, 317-1)

· Investigate the effect of diseases, malformations, and injury on the brain, eye, and ear, and the corresponding mechanical solutions or medical treatments (115-5, 116-4,

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